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Effect of Hydrostatic Pressure on Spin Disorder Resistivity of Heavy Rare Earth Metals

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In order to have the volume dependence of the *s-f* exchange coupling constant $\ln\Gamma/\ln V$ in indirect exchange theory,[1] it is necessary to know both variations in the spin disorder resistivity ρ_s and the paramagnetic Curie temperature θ_p with pressure. This paper is concerned with the estimation of the pressure dependence of ρ_s of heavy rare earth metals Gd, Tb, Dy, Ho and Er, from the measurements of the resistance R as a function of temperature under hydrostatic pressures. The specimens used are of the shape of rod, 1.5 mm in diameter and 25 mm in length, made of polycrystals, 99.9% in purity, purchased from American Potash and Chemical Corp. The measurement was made by a conventional 4-probe method in a temperature range from 150 to 400 K under hydrostatic pressures up to 6 kbar.

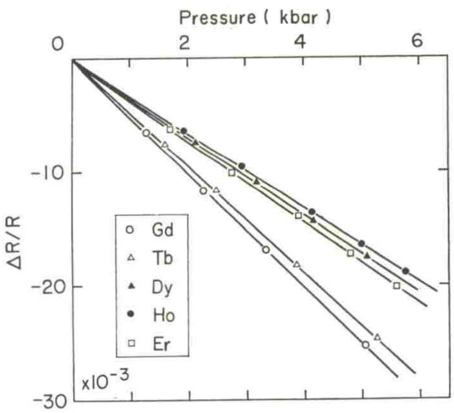

Fig. 1. A plot of the relative resistance, $\Delta R/R$, at room temperature versus pressure.

Figure 1 shows plot of the relative resistance $\Delta R/R$ at room temperature versus pressure. The $\Delta R/R$ appeared to be linear in pressure at all temperatures. The pressure coefficient of the electrical resistivity $(1/\rho)(\Delta\rho/\Delta p)$ is written as

$$(1/\rho)(\Delta\rho/\Delta p)=(1/R)(\Delta R/\Delta p)-K_l\,, \qquad (1)$$

where K_l is the linear compressibility. In the present work K_l was determined by use of a device named compressimeter.[2] In Fig.2 the electrical resistivities at 10 kbar and 1 bar, ρ_{10k} and ρ_0, are plotted as a function of temperature for Tb. Here ρ_0 was measured at all temperatures and ρ_{10k} at temperatures from 150 to 400 K was evaluated from eq. (1) on the assumption that both $(1/R)(\Delta R/\Delta p)$ and K_l are independent of pressure. Almost all the difference between ρ_{10k} and ρ_0 may be attributable to the variation of ρ_s. The values of $\Delta\rho_s$ resulting from the variation in pressure of 10 kbar and ρ_s are estimated by the extrapolation from the paramagnetic temperature range as shown in Fig. 2, so that the

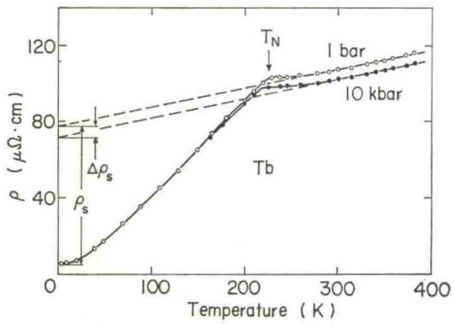

Fig. 2. Electrical resistivity as a function of temperature.

pressure coefficient $(1/\rho_s)(\Delta\rho_s/\Delta p)$ may be obtained.

In Table I are listed the residual resistivity ρ_{res}, ρ_s, $(1/\rho_s)(\Delta\rho_s/\Delta p)$ and $\ln\Gamma/\ln V$. Except for Er, the values of ρ_{res} and ρ_s are in fair agreement with those by Colvin *et al.*[3] In the last column, the value of $\ln\Gamma/\ln V$[4] is given, being estimated by employing the value of $(1/\rho_s)(\Delta\rho_s/\Delta p)$ and that of the pressure coefficient $(1/\theta_p)(\Delta\theta_p/\Delta p)$.[4,5] The ratio of the variation in Γ to that in volume is around one for Gd, Tb and Dy, but for Ho and Er it varies rapidly in order of Ho and Er.

Table I. Data for Gd, Tb, Dy, Ho and Er

	ρ_{res} ($\mu\Omega\cdot$cm)	ρ_s ($\mu\Omega\cdot$cm)	$(1/\rho_s)(\Delta\rho_s/\Delta p)$ (10^{-6}bar^{-1})	$\ln\Gamma/\ln V$
Gd	3.7	99.4	−8.3	1.4
Tb	5.4	72.2	−6.9	1.0
Dy	3.9	49.2	−4.2	0.7
Ho	7.7	31.2	−4.7	2.2
Er	19.5	15.7	−10.6	5.5

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